# GCE

## Physics A

**H156/01:** Breadth in physics

Advanced Subsidiary GCE

# Mark Scheme for November 2020

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Here are the subject specific instructions for this question paper.

## CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

**M** marks These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

**A** marks These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

**C** marks These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

**B** marks These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

## SIGNIFICANT FIGURES

If the data given in a question is to 2 sf, then allow an answer to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Guidance.

Annotations

| Annotation | | Meaning |
|---|---|---|
| | Correct response | Used to indicate the point at which a mark has been awarded (**one tick per mark awarded**). |
| | Incorrect response | Used to indicate an incorrect answer or a point where a mark is lost. |
| **AE** | Arithmetic error | Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors. |
| **BOD** | Benefit of doubt given | Used to indicate a mark awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done. |
| **BP** | Blank page | Use BP on additional page(s) to show that there is no additional work provided by the candidates. |
| **CON** | Contradiction | No mark can be awarded if the candidate contradicts himself or herself in the same response. |
| **ECF** | Error carried forward | Used in numerical answers only, unless specified otherwise in the mark scheme. Answers to later sections of numerical questions may be awarded up to full credit provided they are consistent with earlier incorrect answers. Within a question, ECF can be given for AE, TE and POT errors but not for XP. |
| **L1** | Level 1 | L1 is used to show 2 marks awarded and L1^ is used to show 1 mark awarded. |
| **L2** | Level 2 | L2 is used to show 4 marks awarded and L2^ is used to show 3 marks awarded. |
| **L3** | Level 3 | L3 is used to show 6 marks awarded and L3^ is used to show 5 marks awarded. |
| **POT** | Power of 10 error | This is usually linked to conversion of SI prefixes. Do not allow the mark where the error occurs. Then follow through the working/calculation giving ECF for subsequent marks if there are no further errors. |
| **SEEN** | Seen | To indicate working/text has been seen by the examiner. |
| **SF** | Error in number of significant figures | Where more SFs are given than is justified by the question, do not penalise. Fewer significant figures than necessary will be considered within the mark scheme. **Penalised only once in the paper.** |
| **TE** | Transcription error | This error is when there is incorrect transcription of the correct data from the question, graphical read-off, formulæ booklet or a previous answer. Do not allow the relevant mark and then follow through the working giving ECF for subsequent marks. |
| **XP** | Wrong physics or equation | Used in numerical answers only, unless otherwise specified in the mark scheme. Use of an incorrect equation is wrong physics even if it happens to lead to the correct answer. |
| **^** | Omission | Used to indicate where more is needed for a mark to be awarded (what is written is not wrong but not enough). |

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

| Annotation | Meaning |
|---|---|
| **/** | alternative and acceptable answers for the same marking point |
| **Reject** | Answers which are not worthy of credit |
| **Not** | Answers which are not worthy of credit |
| **Ignore** | Statements which are irrelevant |
| **Allow** | Answers that can be accepted |
| **( )** | Words which are not essential to gain credit |
| ___ | Underlined words must be present in answer to score a mark |
| **ECF** | Error carried forward |
| **AW** | Alternative wording |
| **ORA** | Or reverse argument |

**SECTION A**

| Question | Answer | Marks | Guidance |
|---|---|---|---|
| 1 | A | 1 | |
| 2 | A | 1 | |
| 3 | C | 1 | |
| 4 | D | 1 | |
| 5 | A | 1 | |
| 6 | C | 1 | |
| 7 | C | 1 | |
| 8 | A | 1 | |
| 9 | C | 1 | |
| 10 | B | 1 | |
| 11 | D | 1 | |
| 12 | A | 1 | |
| 13 | A | 1 | |
| 14 | B | 1 | |
| 15 | C | 1 | |
| 16 | B | 1 | |
| 17 | D | 1 | |
| 18 | A | 1 | |
| 19 | C | 1 | |
| 20 | D | 1 | |
| | Total | 20 | |

## SECTION B

**General rule**: For substitution into an equation, allow any subject – unless stated otherwise in the guidance

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 21 | (a) | | momentum | B1 | |
| | | | kinetic energy / total energy | B1 | **Allow** energy / mass |
| | (b) | | (Motion / speed / force / acceleration of person or skateboard is to the) left / opposite direction to ball / 'backwards' | B1 | |
| | | | momentum is conserved / momentum of person = momentum of ball (but in opposite direction) | B1 | **Allow** 'principle of conservation of momentum'<br>**Allow** 'equal and opposite forces (acting on ball and person for the same time interval)' |
| | | | (total) momentum is zero (at start or at the end or during the throwing of the ball) / speed of person < speed of ball | B1 | **Allow** 'different speed'<br>**Allow** velocity |
| | | | **Total** | 5 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 22 | (a) | | $v \rightarrow$ m s$^{-1}$ **or** $v^2 \rightarrow$ m$^2$ s$^{-2}$ | M1 | |
| | | | Clear algebra leading to base unit = kg m$^{-1}$ | A1 | |
| | (b) | | $\frac{0.12}{1.20}(\times 100)$ **or** $\frac{0.24}{4.00}(\times 100)$ **or** ($k$ =) 2.78 (kg m$^{-1}$) | C1 | **Allow** ($k_{max}$ =) $\frac{4.24}{1.08^2}$ and ($k_{min}$ =) $\frac{3.76}{1.32^2}$ **or** 3.635 and 2.158 |
| | | | [2 × 0.1 + 0.06] **or** 0.26 **or** 26 % | C1 | **Allow** (range =) 1.48 |
| | | | absolute uncertainty = 0.72 (kg m$^{-1}$) | A1 | **Note**: The answer must be given to 2 SF – as required by the question<br>**Ignore** any value given for $k$ on the answer line |
| | | | **Total** | 5 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 23 | (a) | (i) | Straight line drawn from the bottom of the 9.0 m s$^{-1}$ vector to the end of the 4.2 m s$^{-1}$ vector | B1 | **Ignore** incorrect / omitted direction of resultant vector<br>**Ignore** any other additional lines drawn |
| | | (ii) | $v^2 = 9.0^2 + 4.2^2 - 2 \times 9.0 \times 4.2 \times \cos 50°$<br>$v$ = 7.1 (m s$^{-1}$) | C1<br>A1 | **Allow** other correct variants of this method<br>**Note** answer to 3 SF is 7.07 |
| | | | **OR** | | |
| | | | length of resultant vector line measured **and** some calculations | C1 | **Allow** length of resultant vector in the range 5.4 – 5.6 cm |
| | | | $v$ = 7.1 (m s$^{-1}$) | A1 | **Allow** ± 0.20 (m s$^{-1}$) |
| | (b) | (i) | (stress =) $\frac{7.5}{8.2\times10^{-7}}$ **or** $9.15 \times 10^6$ (Pa) | C1 | **Allow** full credit for alternative methods |
| | | | (strain =) $\frac{7.5}{8.2\times10^{-7} \times 2.0\times10^{11}}$ **or** $4.57 \times 10^{-5}$ | C1 | |
| | | | $x = 2.8 \times 10^{-5}$ (m) | A1 | **Note** answer is $2.84 \times 10^{-5}$ to 3 SF |
| | | | **OR** | | |
| | | | $E = \frac{FL}{Ax}$ | C1 | |
| | | | $2.0 \times 10^{11} = \frac{7.5 \times 0.62}{8.2 \times 10^{-7} \times x}$ | C1 | |
| | | | $x = 2.8 \times 10^{-5}$ (m) | A1 | **Note** answer is $2.84 \times 10^{-5}$ to 3 SF<br>**Special case:** 1 mark for $2.8 \times 10^{-4}$ (m) or $2.9 \times 10^{-6}$ (m); 7.5$g$ or 7.5$g^{-1}$ ($g$ = 9.81) used instead of 7.5 |
| | | (ii) | acceleration at **Y** / deceleration at **Z** | B1 | **Allow** increasing velocity / increasing speed at **Y**<br>**Allow** decreasing velocity / decreasing speed **/** negative acceleration at **Z** / slowing down<br>**Ignore** 'downward acceleration' at **Z**<br>**Ignore** drag throughout |
| | | | At **Y** (tension is) greater / ($T$) > 7.5 (N) | B1 | **Allow** ($T$) > weight |
| | | | At **Z** (tension is) less / ($T$) < 7.5 (N) | B1 | **Allow** ($T$) < weight |
| | | | **Total** | 9 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 24 | (a) | (i) | Systematic error / meter not zeroed (AW) | B1 | **Allow** resistance due to crocodile clips / resistance of connecting wires / internal resistance (of cell in ohmmeter) / resistance of ohmmeter |
| | | (ii) | Use a vernier calliper / micrometer to measure diameter of pencil lead (and hence determine $A$) | B1 | **Allow** vernier / calliper |
| | | | $\rho$ = gradient of line $\times$ $A$ (Any subject) | B1 | **Allow** use of 'slope' for gradient |
| | | | Any **one** from:<br>• $A = \frac{\pi d^2}{4}$<br>• Measure the diameter in several positions (and average)<br>• Use a large 'triangle' to determine the gradient | B1 | **Allow** $A = \pi r^2$ and $d = 2r$ |
| | (b) | (i) | $(\frac{1200}{300})$<br>4.0 | B1 | **Allow** 1 SF |
| | | (ii) | $180 = \frac{\rho \times 25}{6.7 \times 10^{-8}}$ | C1 | |
| | | | $\rho = 4.8 \times 10^{-7}$ ($\Omega$ m) | A1 | **Note** answer is $4.82 \times 10^{-7}$ to 3 SF |
| | | | **Total** | 7 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 25 | (a) | | Current less | B1 | |
| | | | Cell has internal resistance **or** greater (total) resistance **or** p.d. across internal resistor **or** p.d. across resistor/10.0 (Ω) | B1 | **Allow** 'lost volts' / power lost in cell<br>**Ignore** wires have resistance |
| | (b) | | ($V_A$ =) 6.0 (V) **or** ($R_A$ =) 30 (Ω) | C1 | |
| | | | For parallel lamps, any one from:<br>($V_{\|\|}$ =) 2.0 (V) **or** ($I$ =) 0.10 (A) **or** ($R_L$ =) 20 (Ω) **or** ($R_{\|\|}$ =) 10 (Ω) | C1 | **Not** $R_{\|\|}$ = 15 (Ω); this is XP |
| | | | resistance = 40 (Ω) | A1 | |
| | | | **Total** | **5** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 26 | (a) | | constant phase (difference of 90°) | B1 | **Ignore** incorrect value<br>**Ignore** same wavelength / frequency / period |
| | (b) | | (period =) 4.0 (ms) | C1 | |
| | | | ($f$ = 0.004$^{-1}$) | | |
| | | | $f$ = 250 (Hz) | A1 | **Allow** 1 mark for 0.25; k omitted |
| | (c) | | (intensity =) $\left(\frac{24}{10}\right)^2 (I_0)$ | C1 | |
| | | | intensity = 5.8 ($I_0$) | A1 | **Not** $\frac{144}{25} I_0$<br>**Allow** 1 mark for 4.84; misread graph and used $(\frac{22}{10})^2$ |
| | (d) | | resultant displacement = 10 (μm) | B1 | **Allow** ± 1.5; **Ignore** sign |
| | | | **Total** | **6** | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 27 | (a) | | (At the point where two or more waves meet the) resultant displacement is equal to the sum of the individual displacements (of the waves) | B1 | **Allow** sum / net / total for resultant<br>**Ignore** vector sum<br>**Not** amplitude |
| | (b) | | Maxima is when constructive (interference) occurs / phase difference is zero / path difference = $n\lambda$<br><br>Minima is when destructive (interference) occurs / phase difference is 180(°) or $\pi$( rad) / path difference = $(n + ½)\lambda$ at minima | B1<br><br>B1 | **Allow** 'completely in phase' for phase difference is zero<br><br>**Allow** 'antiphase'/ 'completely out of phase' for phase difference is 180(°)<br><br>**Allow** 1 mark for 'constructive and destructive (interference)', without any link to the maxima and minima |
| | (c) | | ($x$ =) 200 × 18 **or** ($x$ =) 3600 (m)<br><br>($\lambda$ =) $\frac{120 \times 3600}{2400}$<br><br>$\lambda$ = 180 (m) | C1<br><br>C1<br><br>A1 | **Not** $v = f\lambda$ ; 18 = $\frac{1}{200} \times \lambda$ **or** $\lambda$ = 3600 (m)<br><br>**Allow** 3600 m from $v = f\lambda$ when used as $x$ here<br>**Note** using $x$ = 1800 m is **XP** (this gives 90 m) |
| | | | **Total** | 6 | |

| Question | | | Answer | Marks | Guidance |
|---|---|---|---|---|---|
| 28 | (a) | | Photon mentioned / one-to-one interaction (between electron and photon)<br><br>(Maximum KE of electrons decreases as wavelength increases because) $KE_{(max)} = \frac{hc}{\lambda} - \phi$ (Any subject)<br><br>(When $\lambda < \lambda_0$) energy (of photon) > work function / $f$ > threshold frequency **and** electrons emitted / $KE_{(max)} \neq 0$<br>**or**<br>(When $\lambda = \lambda_0$) energy (of photon) = work function / $f$ = threshold frequency **and** electrons <u>just</u> emitted / not emitted / $KE_{(max)} = 0$<br>**or**<br>(When $\lambda > \lambda_0$) energy (of photon) < work function / $f$ < threshold frequency **and** electrons not emitted / $KE_{(max)} = 0$ | **B1**<br><br>**B1**<br><br>**B1** | **Not** $KE_{(max)} = hf - \phi$ by itself, but **allow** with $\underline{c} = f\lambda$<br><br>**Allow** $\frac{hc}{\lambda}$ **or** $hf$ for 'energy of photon' and $\phi$ for 'work function' for this **B1** mark<br>**Not** $f_0$ for threshold frequency<br><br>**Allow** $\lambda_0$ / threshold wavelength is the <u>maximum</u> wavelength for electrons to be emitted<br>**Allow** threshold frequency is the <u>minimum</u> frequency for electron(s) to be emitted<br>**Allow** work function is the <u>minimum</u> energy for electron(s) to be emitted |
| | **(b)** | **(i)** | $E = \frac{6.63 \times 10^{-34} \times 3.0 \times 10^{8}}{490 \times 10^{-9}}$<br><br>energy = $4.1 \times 10^{-19}$ (J) | **C1**<br><br>**A1** | <br><br>**Note** answer to 3 SF is $4.06 \times 10^{-19}$ |
| | | **(ii)** | (number of photons =) $\frac{0.230}{4.06 \times 10^{-19}}$<br><br>number of photons = $5.7 \times 10^{17}$ | **C1**<br><br>**A1** | Possible ECF from **(b)(i)**<br><br>**Note** answer is $5.6 \times 10^{17}$ when $4.1 \times 10^{-19}$ is used |
| | | | **Total** | **7** | |

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